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Management of Forage Production Under Irrigation

Conducted by

B. Gossen, B. Goplen, J. Soroka and H. Ukrainetz

Funded by the Agriculture Development Fund

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Final Report

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FINAL REPORT 1986 - 90

MANAGEMENT OF FORAGE PRODUCTION UNDER IRRIGATION

ADF PROJECT #R-86-02-~~0400~~ 0040

B.D. Gossen, B.P. Goplen, J.J. Soroka and H. Ukrainetz

EXECUTIVE SUMMARY

Abstract

The program was initiated primarily to examine the causes of low alfalfa seed yields in the Outlook irrigation district. In our trials, seed production was excellent if irrigation was discontinued in late June, control of insect pests was achieved through timely spray applications, and pollination was provided by leafcutter bees. There were significant differences in seed and forage production among the alfalfa varieties/strains tested. Alfalfa fields infected with verticillium wilt were identified and eradication measures were started. Seed production of Kentucky bluegrass was highly variable. Forage production of several grass species was excellent under irrigated conditions.

Impact on Saskatchewan Agriculture

This work demonstrates the suitability of alfalfa seed production for irrigated areas of Saskatchewan, and suggests that seed production of other forage crops e.g. Kentucky bluegrass and other grass species, may also be feasible. Evaluation of the forage production of alfalfa varieties and forage grass species provides information which growers need in order to decide which forage species and cultivars to choose.

Summary

The project was initiated in 1986 on a 4 hectare site on the SIDC farm at Outlook. The project contract was not signed until early June, and irrigation at the site was not available until early July. We attempted to establish nine separate trials that summer, but the delays, coupled with other problems including residual effects of herbicides from previous trials on portions of the study area resulted in an unsatisfactory (i.e. disastrous) initial field season. Uneven establishment due to herbicide residue in the soil was noted in most trials. Several of the trials were plowed down and reseeded in the fall, but did not establish adequately for research use. The area was also extremely weedy. Tillage to control weeds resulted in severe wind erosion of the very light soil in the study area.

Three trials were successfully established in 1986. These were: 1) 1986 Uniform Alfalfa Variety Test (Forage), which examined the forage yield of 31 alfalfa varieties, 2) Cottony Snow Mold Evaluation Trial, which examined the impact of cottony snow mold of alfalfa on 9 varieties, and 3) Alfalfa-Winter Wheat Rotation Study, which examined winter wheat survival following alfalfa in a rotation. In addition, a study to examine the Effect of Alfalfa Stand Density on Seed Production was partially established (2 of 3 replicates). The problems which we experienced with mid-summer establishment of alfalfa emphasized the need to seed the crop early, when soil moisture levels are higher and surface drying is generally less rapid.

In 1987, after another unsuccessful attempt to establish alfalfa in the herbicide-affected portions of the plot area, we were allocated additional land adjacent to the original site, and five new trials were established: 1) 1987 Uniform Alfalfa Variety Test (Forage), with 27 lines, 2) 1987 Uniform Alfalfa Variety Test (Seed), with 27 lines, 3) Kentucky Bluegrass Seed Production, with 3 varieties and 2 lines, 4) Forage Grass Species Trial (Forage), with 12 varieties (7 species), and 5) Fertilizer Requirements for Alfalfa Seed Production. The fertility trial was established at Saskatoon, because our unsuccessful attempts to establish this test at SIDC had used up all the land that was suitable for this trial. In addition, two studies: 1) Effect of Soil Fertility on Alfalfa Forage Yields, and 2) Effect of Cutting Management on Root Diseases of Alfalfa, could not be established at SIDC because there was not sufficient land available.

In 1987, our first forage cuts were taken from the tests established in 1986 and preliminary results suggested that with appropriate irrigation scheduling (Table 1), and chemical spray programs to control insect pests, alfalfa seed production could be highly successful in the Outlook area.

In 1988 and 1989, alfalfa seed production was excellent, with a mean yield in the 1986 Uniform Alfalfa Variety Test of 750 kg/ha in 1988 and 524 kg/ha in 1989. Kentucky bluegrass seed yields were low, but the high variability between years and locations suggests that the potential for higher yields exists. Forage yields were taken on the forage trials. A second trial to assess forage grass species for forage yields under irrigation was established in 1988. In 1989, we successfully established a trial on the periphery of the area which had previously shown herbicide residual activity to examine the effect of cutting management on alfalfa root diseases. Many of the varieties in the 1986 Uniform Alfalfa Variety Trial (Forage) suffered severe winter kill in the winter of 1988-89. Varieties recommended in Saskatchewan generally exhibited the highest percentage survival. Data on

survival and vigor following severe winters is extremely important in evaluating the suitability of varieties for Saskatchewan conditions.

Verticillium wilt, one of the most important diseases of alfalfa in Europe and North America, was found in irrigated alfalfa fields in southwestern Saskatchewan. Eradication of the disease from affected fields by ploving and crop rotation either has been initiated or is planned for all affected fields.

There was no effect of fertilizers on seed yield in our trials to date. However, the inital fertility of the sites was quite high, and we will continue this study for at least two more years.

TECHNICAL REPORT

ABSTRACT

Uniform Alfalfa Variety Tests: Uniform alfalfa forage and seed variety tests were seeded in 1986 on the assigned forage research block at SIDC. Germination and seedling emergence occurred as expected but within two weeks the newly emerged seedlings died in large areas of the tests. It became apparent that the southern quarter of the block had toxic herbicide residue in the soil. The area affected corresponded to a crop of potatoes grown previously and treated with a pre-plant herbicide. The 1986 alfalfa seed test was in the affected area and was subsequently discarded. However, the 1986 alfalfa forage test was located north of the toxic area and established successfully. There were significant differneces in yield and winter survival among the varieties tested. A new alfalfa seed test was seeded in 1987 in a residue-free area and establishment was excellent. Very high seed yields were obtained in 1988 (mean 750 kg/ha) and 1989 (mean 530 kg/ha). There were significant differences in seed production among the strains and advanced lines in both years.

Stand Density Trial: Irrigated Beaver alfalfa was grown for seed production in 0.9 ha plots at SIDC from 1987 to 1989. Average seed production over all three years was 446 kg/ha. No significant correlation was developed between plant density and yields; on a per m^2 basis the thinnest stands had the lowest yields in two years. Plant bugs surpassed the economic threshold and were controlled in all three years. Leafcutter bee cell replication averaged approximately 3.3 times the amount of bees set out in the summer.

Diseases: Verticillium wilt (*Verticillium albo-atrum*) was identified in the south-western region of the province, and an eradication program has been initiated. Spring black stem (*Phoma medicaginis*) is the predominant foliar pathogen of alfalfa in central and southern regions. Cottony snow mold (*Coprinus psychromorbidus*) is not an important factor contributing to winter kill of alfalfa under irrigation in central and southern Saskatchewan.

Forage Grasses: Yields of Kentucky bluegrass seed have been low and highly variable between years and locations, but the stands appear healthy and vigorous. Agronomy work is needed to increase the yield of this crop. First and second year data from two forage grass species trials demonstrate that very high forage yields (>10,000 kg/ha DM) are possible with several species when adequate fertility is maintained.

GENERAL

The project was initiated in the summer of 1986 on a 4 hectare site on the SIDC farm at Outlook. The project contract was not signed until early June, and irrigation at the site was not available until early July. These delays, coupled with numerous other problems, resulted in an initial field season which can only be described as disastrous. We attempted to establish nine separate trials that summer. A combination of surface drying, wind erosion, grasshopper infestation and herbicide residues from previous studies on the south and west ends of the study area resulted in complete failure or uneven establishment of most of the trials. Several of the trials in the herbicide-affected areas were plowed down and reseeded in the fall, but did not establish adequately for research use. The area was also

extremely weedy. Tillage to control weeds resulted in severe wind erosion of the very light soil in the study area.

Three trials on the north side of the plots were successfully established in 1986. These were: 1) 1986 Uniform Alfalfa Variety Test (Forage), which examined the forage yield potential of 31 alfalfa varieties in a 5-replicate randomized complete block design (RCBD), 2) Snow Mold Evaluation Trial, which examined the impact of cottony snow mold of alfalfa on nine varieties under irrigated conditions in a 4-replicate split plot RCBD, and 3) Alfalfa-Winter Wheat Rotation Study, which examined winter wheat survival in a rotation following alfalfa which had been inoculated with cottony snow mold in a 4-replicate RCBD. In addition, a study to examine the effect of alfalfa stand density and leafcutter bee activity on seed production was partially established (2 of 3 replicates). Our experience with mid-summer establishment of alfalfa emphasizes the need to seed alfalfa early, when soil moisture levels are higher and surface drying is generally less rapid.

In 1987, following another unsuccessful attempt to establish alfalfa in the herbicide-affected southern portions of the plot area, we were allocated additional land adjacent to the original site. Establishment on this new land was generally highly successful. Five new trials were established in 1987: 1) 1987 Uniform Alfalfa Variety Test (Forage), with 30 lines in a 4-replicate RCBD, 2) 1987 Uniform Alfalfa Variety Test (Seed), with 27 lines in a 5-replicate RCBD, 3) Kentucky Bluegrass Seed Production, with 3 varieties and 2 lines in a 4-replicate RCBD, 4) Forage Grass Species Trial (Forage), with 12 varieties (7 species) in a 4-replicate RCBD, and 5) Fertilizer Requirements For Alfalfa Seed Production, in a 4-replicate RCBD.

In 1986, the fertility trial had been located in the area affected by herbicide residue. An attempt to establish the trial on the new land allocated in 1987 was our only failure. Once a site has been treated with fertilizer during the preparation of a fertility trial, it cannot be used for fertilizer studies for several years. As a result, there was no suitable land at the SIDC site available for the study. The trial was established on the research farm of the Agriculture Canada Research Station at Saskatoon, but soil fertility at that site was relatively high. In addition, two studies: 1) Effect of Soil Fertility on Alfalfa Forage Yields, and 2) Effect of Cutting Management on Root Diseases of Alfalfa, could not be established at SIDC because there was not sufficient land available. Land that was available to us had establishment problems which we have attributed to herbicide residues.

In 1987, our first forage cuts were taken. Preliminary results from one seed test suggested that with appropriate irrigation scheduling (Table 1), and chemical spray programs to control insect pests, alfalfa seed production could be highly successful in the Outlook area. Verticillium wilt, one of the most important diseases of alfalfa in Europe and North America, was found in irrigated alfalfa fields in southwestern Saskatchewan. Mr. H.C. Craig, one of the originators of the project, retired early in 1987. His investigations for the project were taken over by Dr. J.J. Soroka in 1988.

Table 1. Precipitation and irrigation at the SIDC research site, Outlook, 1987-89.

	1987		1988		1989	
	Prec.¶	Irr.§	Prec.	Irr.	Prec.	Irr.
May	2.5	5.8	2.8	7.8	9.5	7.7
June	5.1	5.1	2.7	9.0	1.8	15.4
July	9.7	0.0	3.3	9.0	1.2	10.3
August	7.2	2.5	5.3	2.6	4.8	10.3
September	0.0	0.5	0.1	2.6	2.7	0.0
Total	24.5	13.9	14.2	31.0	20.0	43.6

¶ Prec. = precipitation Irr. = Irrigation.
§ Irrigation of seed trials was discontinued in late June each year, when the leafcutter bees were set out.

In 1988, alfalfa seed production was excellent, with mean yields of 750 kg/ha in the 1987 Uniform Alfalfa Variety Test and 580 kg/ha in the Stand Density Trial. Kentucky bluegrass seed yields were low, with a mean of only 61 kg/ha. Forage yields were taken on the forage trials. A second trial to assess forage grass species for forage yields under irrigation was established.

In 1989, alfalfa seed yields were again very good in our trials, with means of 524 kg/ha in the Uniform Alfalfa Test and 470 kg/ha in the Stand Density Trial. Many of the varieties in the 1986 Uniform Alfalfa Variety Trial (Forage) suffered severe winter kill. That trial was rated for spring survival and vigor, and then plowed down. However, the survival data is extremely important in evaluating lines for their suitability for Saskatchewan growing conditions. There has been a noticeable reduction in the inhibition of alfalfa germination in the herbicide-affected portions of our main plot area. We successfully established a trial to examine the effect of cutting management on alfalfa root diseases in this area in 1989. Seed yield of Kentucky bluegrass almost doubled to 113 kg/ha. The bluegrass plots were burned after harvest to stimulate the production of flowering tillers, and this trial will be continued for at least one more year.

In 1986, we had two summer students in July and August commuting from Saskatoon when work was required at SIDC. In 1987, we stationed a supervisor and a summer student full-time at the SIDC site, and as a result our weed control and other management operations were more timely and effective. We also had one summer student working at the Agriculture Canada Research Station at Saskatoon to provide laboratory backup for the project. This system was continued in 1988 and 1989.

ALFALFA SEED PRODUCTION TRIALS

I. Background and objectives

Uniform Alfalfa Variety Tests are co-operative tests which are used to evaluate new alfalfa lines under a wide range of conditions to determine their suitability for production in Saskatchewan.

Stand Density Trial: Alfalfa was grown for seed production in irrigated areas near Outlook in the 1970's with limited success. The reasons for lack of satisfactory seed yields were never ascertained, although improper timing of irrigation and the possibility of pollinator inefficiency because of the exposed, windy nature of the area were implicated as two main factors (Goplen and Sonmor, 1976). A research project at the SIDC site was undertaken incorporating alfalfa seed production management strategies similar to those utilized in southern Alberta (Krogman and Hobbs, 1977; Hanna et al., 1987) to determine the feasibility of production of Beaver alfalfa seed under irrigation. Management strategies included heavy irrigation until the prebud stage of plant growth and no irrigation thereafter, and vigorous weed and insect control.

Effect of fertilizers: The objective of the study was to determine if fertilizer rates, placement methods and time of application have an effect on alfalfa seed yields under irrigation, either by increasing yields or by maintaining high yields over the period of study.

II. Experimental Methods

1987 Uniform Alfalfa Test (Seed): An alfalfa variety seed test was established under irrigation at Outlook in 1987 to compare seed yields among varieties. The test consisted of 27 varieties with 5 replicates and plots seeded at a rate of 1.5 lb./acre in a single row 20 feet long and spaced 3 feet apart. Establishment was excellent in the seedling year. The stand in the spring of 1988 was judged to be too dense for good seed production and so it was cross-cultivated with 7-inch shovels to reduce the stand approximately 30%. An insecticide was applied for lygus bug control prior to flowering. Leafcutter bees were supplied in late June at a rate of 20,000/acre. The test area was irrigated heavily in late May and early June and irrigation was suspended from mid-June to late September. This irrigation regime is recommended to provide a maximum reserve of water in the soil up to the late bud stage, with subsequent increasing water stress to reduce vegetative growth and promote flowering and nectar production for pollination and seed set. The seed test was treated with a desiccant in mid-September and combined approximately ten days later. The same basic schedule was followed in 1989 except the stand was not cross-cultivated as it was deemed to be of acceptable stand density from the previous year's cultivation.

Stand Density Trial: The following factors influencing production of alfalfa seed were assessed: stand density, pollination and bee behavior, and alfalfa seed insect pests. Plots were broadcast or row seeded in 1986 in a 3-replicate RCBD at a 2 kg/ha seeding rate. Fall cultivation to decrease plant densities by 50% resulted in the following four treatments, listed in order of decreasing plant stand density: solid (broadcast) seeded (SS), row seeded (RS), solid seeded and cultivated (SSC), and row seeded and culti-

vated (RSC). Some plots of the three replicates were reseeded and recultivated in 1987 because of stand establishment problems. Leafcutter bees were placed in the plots at a rate of 20,000 bee cells per acre as the alfalfa came into bloom each year. The activities of the bees were monitored daily; the number of bees entering tunnels per minute and the number of capped tunnels in a specific area of each nest box were counted. In each year the plots were swept with an insect net (38 cm dia.) and the kinds of insects and numbers per sweep were determined throughout the season. In 1988 and 1989, nine and five fields, respectively, of forage alfalfa in the Outlook area were also sampled weekly to determine if the insect fauna in the SIDC plot varied appreciably from that of neighbouring forage fields. In May of 1988 and 1989, the number of shoots in five 1 m^2 areas in each plot were counted. The seed yields from similar areas in 1988 and the same areas in 1989 were determined by hand harvesting. In all three years, the entire plots were harvested with a Hege harvester and the total yield per plot was determined. The bee increase was determined by comparing the weight of cocoons set out in spring with that harvested at the end of the season. Representative samples of the cells were analyzed by W. Goerzen, consultant to the Saskatchewan Alfalfa Seed Producers Association.

Effect of fertilizers: Plots were seeded and established in the spring of 1987 on a Sutherland clay soil at Saskatoon. The soil site was sampled prior to fertilizer application and seeding, and the soil test data are given in Table 2. Soil analyses showed that the levels of available N, P, K and S were adequate to very high. At these levels, immediate response to fertilizers would not be expected.

Alfalfa cv. Beaver was seeded at the rate of 1 kg/ha with 68 cm row spacing. The fertilizer treatments applied are shown in Table 8. Treatments 1 - 7 were sidebanded at time of seeding, treatment 8 was broadcast and incorporated before seeding, and treatments 9 - 16 were broadcast in the spring of 1988. In the spring of 1989, fertilizer combinations 1 - 7 with the P rates increased to 40 kg/ha, were again applied by broadcasting on the surface of the plots. Treatments 9 - 16 were also re-applied at this time. Adequate populations of leafcutter bees were provided on the plot area in both years.

Table 2. Soil analyses for alfalfa test site, 1987

Depth (cm)	pH	Kg/ha N	P	K	S
0 - 15	7.3	40	83	706	8
15 - 30		22	38	437	7
30 - 45		16	18	392	8
45 - 60		13	17	381	9

III. Results and Discussion

1987 Uniform Alfalfa Test (Seed): Seed yields from this test were very high in both 1988 and 1989 as shown Table 3. The 1988 seed yields ranged from 494 - 978 kg/ha with an average of 753 kg/ha (650 lb./ac.), and the 1989 seed yields ranged from 295 - 675 kg/ha with an average of 524 kg/ha (466 lb./ac.). This compares very favorably with an average seed yield of 390 kg/ha (350 lb./ac.) in the irrigated alfalfa seed production area of southern Alberta.

Alfalfa varieties differ in seed production but the variation is considerable even between years for a given variety. These data should be viewed as preliminary since they are taken from two years on one site. However, most of the recommended varieties are in the upper range in seed yield and the overall seed yield compares very favorably with the main irrigated alfalfa seed production area of southern Alberta.

Stand Density Trial: The summer of 1987 was predominantly cool and cloudy, so that conditions for pollination of alfalfa flowers were not optimal. Seed yields were low, averaging 280 kg/ha (250 lb/ac). In this year, the plot with the lowest stand density, RSC (Table 4), had the highest yields, but within plot variation was as great as between plot variation in yield, and differences in seed yield among plots were not significant. The summer of 1988 was hot and dry, which resulted in excellent pollination activity of the leafcutter bees and average alfalfa seed yields of 583 kg/ha (519 lb/ac). In this, the first production year from all replicates, the plot with the thinnest stands had the lowest yields, but again the differences in yield among treatment were not significant. In 1989, favourable weather conditions and good bee activity led to average seed yields of 474 kg/ha over all plots. By the end of the 1989 growing season, self-seeding within the plots had resulted in filling in of the plant canopy, so that the treatments were visually indistinguishable. This was reflected in average yields among treatments, which were very similar (Table 4).

When yield data were combined over all three years, yield differences among treatments were not significant. The year, however, had a profound effect on seed yields ($P < 0.01$). This may have been expressed directly, upon the growth, vigour, and seed set capabilities of the plants, and indirectly, by influencing the pollinating capabilities of the leafcutter bees.

Differences in yield per m^2 among treatments were significant at $P = 0.10$ in both 1988 and 1989, and when data were combined over years (Table 5). In both years the RSC plots, those with the thinnest stands, had the lowest yields. Seed yield in solid seeded plots tended to be higher than row seeded plots in these two years. Yields from m^2 samples were low in 1989 because of shelling during sweep net sampling and because of the propensity of samples to be in the path of the irrigation line wheels. Linear regressions of seed yield upon stand density were not significant.

Table 3. 1987 Uniform Alfalfa Test - Seed Yields.

Cultivar	1988 Seed Yields (kg/ha)	1989 Seed Yield (kg/ha)	Mean Seed yield(kg/ha)
AP 40	962 (120)[¶]	615 (117)	789 (118)
NAPB 32	910 (114)	650 (124)	780 (117)
OAC Minto	978 (122)	533 (101)	756 (113)
Victoria	821 (102)	675 (128)	748 (112)
Primal	804 (100)	622 (118)	713 (107)
Anchor	760 (95)	654 (124)	707 (106)
Rambler	913 (114)	499 (95)	706 (106)
Glory	810 (101)	565 (107)	688 (103)
WL 222	857 (107)	516 (98)	687 (103)
Beaver	801 (100)	526 (100)	664 (100)
NAPB 31	747 (93)	571 (109)	659 (99)
Arrow	715 (89)	595 (113)	655 (98)
Apica	834 (104)	476 (90)	655 (98)
NK 83632	679 (85)	579 (110)	629 (94)
A 872	691 (86)	546 (104)	619 (93)
Alouette	709 (88)	512 (97)	611 (92)
WL 316	621 (77)	591 (112)	606 (91)
Barrier	695 (87)	488 (93)	592 (89)
Vernal	664 (83)	499 (95)	582 (87)
Riel	747 (93)	570 (108)	659 (86)
Oneida VR	644 (80)	507 (96)	576 (86)
Spredor II	766 (96)	379 (72)	573 (86)
VW-34-2	673 (84)	440 (84)	557 (83)
Maxim	625 (78)	472 (90)	549 (82)
BLM-1019	793 (99)	295 (56)	544 (82)
80-16P	622 (78)	422 (80)	522 (78)
Sitel	494 (61)	350 (67)	422 (63)
Mean	753	524	639
F Value	2.03	1.49	
C.V. (%)	21	32	
L.S.D. (.05)	225	212	

[¶] Figures in brackets refer to % of seed yield of Beaver alfalfa.

Table 4. Mean seed yield from alfalfa grown under different plant densities in 0.90 ha plots at Outlook, 1987-89 (n=3).

Treatment	Yield (kg/ha)			
	1987	1988	1989	Mean
Solid Seeded	233.3	707.6	488.9	477
Solid Seeded, Cultivated	197.0	606.8	472.7	426
Row Seeded	306.0	620.9	476.7	468
Row Seeded, Cultivated	381.8	395.1	456.5	411
Mean	279.7	582.6	473.7	446

Table 5. Seed yield from 1 m^2 samples of alfalfa grown under different plant densities at Outlook, 1988-89.

Treatment	1988		1989		Mean Yield (kg/ha)
	Shoots ($per\ m^2$)	Yield (kg/ha)	Shoots ($per\ m^2$)	Yield (kg/ha)	
Solid Seeded	325	909.0 a[¶]	418	273.8 ab	591.4 a
Solid Seeded, Cultivated	235	903.5 a	172	389.5 a	646.4 a
Row Seeded	310	633.0 b	379	340.1 a	486.6 ab
Row Seeded, Cultivated	171	541.0 b	143	181.3 b	361.2 b
Mean Yield		746.6		296.2	521.4

[¶] Means followed by the same letter in the same column are not significantly different at the P=0.10 level of probability based on L.S.D. tests.

In all three years, numbers of lygus and alfalfa plant bugs prior to the placement of leafcutter bees in the fields were over the economic threshold of 5 per sweep (Fig 1). Therefore, insecticides for control of insect pests were applied to the plots several days before bee placement each year. Pea aphid numbers rose in late July and August, especially in 1988, but did not appear to affect seed yield. The species composition of insect fauna occurring in the alfalfa seed field was similar to that found in the neighbouring forage fields. The numbers of insects such as pea aphids were generally lower over the season in the forage fields than in the seed field because of the disruption of the insects caused by the cutting of forage.

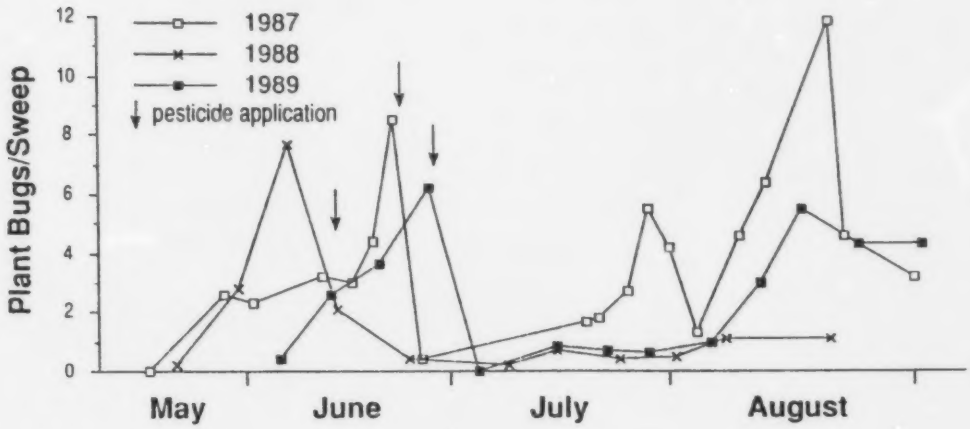

Fig. 1 Lygus and alfalfa plant bug populations in an alfalfa seed field, Outlook, 1987 to 1989.

Particular attention was paid to collecting the many small Hymenoptera from the sweep net samples. Some of these species are parasites of lygus bugs and other plant bugs, which are the main insect pests of alfalfa seed production. Others may be parasites of leafcutter bee larvae. In 1989, parasitism of lygus and alfalfa plant bugs from forage alfalfa fields in the Outlook area ranged from 0 to 16% and the rate of parasitized plant bugs from the SIDC seed field on June 26 was 4.3%. This was lower than the 8% rate found in 1987, but in the range found by Moline (1983, cited in Craig and Loan, 1987), who reported a parasitism rate of 2 to 83% in lygus populations from 43 southern Alberta alfalfa seed fields. Identification of the unknown Hymenoptera from these samples is being made by personnel at the Biosystematic Research Centre in Ottawa.

Leafcutter bee activity was positively correlated with temperature and hours of sunshine. This was reflected in the amount of bee cell increase in the three years (Table 6). Analysis of samples of leafcutter bee cells revealed levels of healthy prepupae which were similar in all three years but which were below Saskatchewan averages in terms of live weight of bees per kg (Table 7). Ascosphaera aggregata mold was not found, but the incidence of parasitism was relatively high in both 1988 and 1989, an indication that conditions good for leafcutter bees (5X increase in 1988 and 3.9X increase in 1989) were also good for parasitic wasps. The precise cause of pollen balls in leafcutter bee nests is unknown. A high incidence of pollen balls

Table 6. Number of sunshine hours in July and leafcutter bee cell production, Outlook, 1987 to 1989.

	1987	1988	1989
Sunshine (hours)	230.8	351.7	309.4
Bee cells harvested (kg)	8.1	30.2	23.4
Bee cell increase	1.4X	5.0X	3.9X

Table 7. Quality factors of leafcutter bees from Outlook expressed as a percentage of the total sample, and a comparison with mean values from across Saskatchevan.

Category	1987		1988		1989	
	SIDC	Sask.[¶]	SIDC	Sask.	SIDC	Sask.
Healthy prepupae	69.6	76.2	69.4	79.6	70.5	78.3
Dead larvae/prepupae	2.8	4.8	8.6	4.1	8.4	4.4
Moldy cocoons	6.6	6.4	0.7	2.8	1.3	3.7
Parasitized larvae	0.1	0.5	3.6	2.1	4.4	1.4
Second generation larvae	0.1	1.4	0	0.6	0.6	1.0
Pollen balls	19.7	9.6	16.3	9.3	14.3	9.5
Crushed cocoons	1.0	0.7	1.3	1.3	0.4	1.2
Other	0	0.4	0	0.2	0.1	0.3
Live count/kg	8368	8752	7785	8922	8052	8852
No. of locations	1	59	1	71	1	40

[¶] Data from Goerzen (1990).

may be related to stress; in extreme heat, eggs and very young larvae may die and leave cells with only pollen in them. Factors intrinsic to the alfalfa plant itself may contribute to the incidence of pollen balls. The bees would not have sold for a premium price because of the relatively low number of live prepupae per kg of cells in our samples. However, even if the price obtained was at the low end of the usual range of $0.005 to $0.015 per bee, the income generated from the extra production of bees would be substantial, because of the relatively high numbers of cells produced.

Acknowledgements: Thanks are extended to the alfalfa forage growers who allowed their fields to be sweep net sampled for this study. The work of D.W. Goerzen in analyzing bee cells is greatly appreciated.

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Effect of fertilizers: Seed yields for 1988 and 1989 are given in Table 8. There were no significant differences in seed yields of alfalfa among fertilizer treatments in both years. On the basis of the soil tests, yield increases from fertilizer were not expected, at least in the first year or two of the study.

This field study will be continued for at least two more years to determine how long initial soil fertility levels will maintain high yields of seed and the effect of the fertilizer treatments on stand longevity and seed yields during the period of the study.

Table 8. Effect of fertilizer treatments on seed yields of Beaver alfalfa under irrigation, Saskatoon.

	Fertilizer Treatment kg/ha					Application¶	Seed Yield (kg/ha)	
	N	P	K	S	B/Mo		1988	1989
1.	0	0	0	0	0		636	557
2.	0	20	50	25	0	SB	610	594
3.	0	20	50	0	0	SB	608	523
4.	0	0	50	25	0	SB	649	702
5.	25	20	50	25	0	SB	608	589
6.	0	20	50	25	2.5-B	SB	522	629
7.	0	20	50	25	Mo[δ]	SB	583	632
8.	0	40	100	25	0	BRI	588	658
9.	0	0	50	25	0	BR	693	733
10.	0	20	50	25	0	BR	566	532
11.	0	40	50	25	0	BR	658	606
12.	0	80	50	25	0	BR	592	665
13.	0	40	0	25	0	BR	715	746
14.	0	40	50	0	0	BR	656	554
15.	0	40	50	50	0	BR	503	516
16.	50	40	50	50	0	BR	617	666
L.S.D. (P = 0.05)							N.S.[§]	N.S.
C.V. (%)							17.7	22.5

¶ SB - banded 2.5 cm below x 2.5 cm to side of seed; BRI - broadcast and incorporated before seeding; BR - broadcast on surface after establishment.
§ N.S. - not significant at P = 0.05.
δ 400 g/ha sodium molybdate.

Alfalfa Forage Production Trials

I. Background and objectives

Uniform Alfalfa Variety Tests are co-operative tests which are used to evaluate new alfalfa lines under a wide range of conditions to determine their suitability for production in Saskatchewan.

Effect of fertilizers: The objective of the study was to determine if fertilizer rates, placement methods and time of application have an effect on alfalfa forage yields under irrigation, either by increasing yields or by maintaining high yields over the period of study. Two attempts were made to establish this trial at SIDC, but both resulted in failure (see page 5). No additional land was available for this trial, and so it was not continued.

II. Experimental Methods

1986 Uniform Alfalfa Test (Forage): The 1986 alfalfa variety forage test was established at SIDC with 31 varieties and 4 replicates. The plot size was 1.3 x 6m consisting of 4 rows spaced 0.3 apart, seeded at a rate of 8 kg/ha. All entries established well except for S-7644 (old seed source, reduced germination). Forage yields were taken over two cuts (June 25, August 7) in 1987 and over three cuts (June 21, July 26, September 8) in 1988. Considerable winterkilling occurred over the winter of 1988-89 and hence no forage yields were taken in 1989. As a consequence, the % winterkill was recorded in early June of 1989 and the test was then ploughed up.

1987 Uniform Alfalfa Test (Forage): A second uniform test was established in 1987 with 27 varieties/strains and 5 replicates. Two forage cuts (June 21, July 26) were obtained in 1988 and three cuts (July 4, August 2 and September 27) in 1989.

III. Results and Discussion

1986 Uniform Alfalfa Test (Forage): The forage yields relative to Beaver as 100% are recorded in Table 9 for 1987 and 1988 and the percent winterkill recorded in spring 1989.

It was of interest to note that the Beaver check variety was at or near the top in forage yield in both 1987 and 1988. It is of even greater interest to note the differential winterkill among varieties. Those varieties bred and recommended for Western Canada generally exhibited much more winter hardiness (i.e. Beaver, Peace, Rambler, Heinrichs). Those varieties of Flemish origin (early, quick recovery types) and most new strains and non-recommended varieties were less hardy.

1987 Uniform Alfalfa Test (Forage): The 1989 data and the two-year average in forage yields are presented in Table 10. Although these data are fairly preliminary, varieties recommended in Saskatchewan produced good forage yields in relation to all the lines in the test. In addition to forage yield, producers should note the relative winter hardiness of a variety when choosing a variety. Provincial variety recommedations are based on data

from tests from across the province and are the best source of information for deciding which variety to grow. As more data accumulates from irrigated tests at Outlook, farmers will be assured of the most up-to-date information on new varieties and can be more confident of the results since they come from their own area of the province.

Table 9. Mean Forage Yields (% of Beaver) and Winterkill in 1986 Uniform Alfalfa Test, 1987-89.

Cultivar	1987	1988	% Winterkill Spring 1989¶
Beaver	100	100	13
Champ	86	95	88
Anchor	96	94	30
Peace	102	94	11
526	98	91	41
83-B37	82	91	69
532	90	89	23
NRG 8301	87	87	10
Dart	100	87	65
83-B27	103	87	69
WL 222	101	86	25
WL 225	85	85	81
83-B32	85	84	58
Impact	94	83	48
AP 46	91	82	76
Rambler	85	82	24
Husky	82	82	48
Vernal	95	81	38
Apica	93	81	39
84-14	97	80	61
83-B35	87	79	46
LSC 657	99	79	41
WL 221	85	79	58
Barrier	81	77	34
VW-34-2	86	76	53
84-15	92	76	68
VS-34	81	76	75
84-24	90	76	51
Heinrichs	99	76	11
S-7644	72	65	35

¶ This test was ploughed down in 1989 as a result of the severe winter injury experienced by some lines.

Table 10. Forage Yields and Spring Vigor in the 1987 Uniform Alfalfa Variety Test, 1988-89.

Cultivar or Strain	Spring 1989 Stand (%)	Spring 1989 Vigor[1] (1-9)	Forage Yield - kg/ha Cut 1 Jul 04	Cut 2 Aug 02	Cut 3 Sep 27	Total	2 year Average kg/ha	2 year Average % of Beaver
BLM 1019	95	2	4799	3148	2110	10057	9251	109
Riel	90	3	4382	3705	2635	10092	9228	109
NAPB 31	91	3	4505	2816	2547	9868	8943	106
Apica	93	3	3962	2947	2726	9634	8906	105
Arrow	91	3	4317	2941	2695	9953	8879	105
OAC Minto	92	2	4637	3112	2121	9870	8552	101
A 872	85	4	4148	2771	2631	9550	8517	101
Anchor	96	3	3908	3279	2500	9687	8487	100
Beaver	**95**	**3**	**4151**	**2989**	**1814**	**8954**	**8469**	**100**
Primal	85	3	4124	2634	2413	9170	8460	100
Rambler	93	3	4271	2521	1789	8581	8394	99
Glory	86	3	3723	2752	2506	8980	8391	99
Maxim	78	3	3824	2846	2272	8942	8371	99
80-16 P	91	3	3946	2993	2781	9719	8323	98
Spredor 2	95	2	4058	2598	1996	8652	8304	98
Vernal	92	3	4106	2610	2376	9092	8253	97
VW-34-2	89	3	4152	2611	2232	8995	8024	95
WL 316	84	3	3640	2846	2306	8793	8020	95
Alouette	88	3	3901	2592	2426	8920	7990	94
Victoria	69	3	3281	2236	2213	7730	7913	87
NK 83632	86	4	3724	2614	2451	8788	7896	93
WL 222	90	3	3661	2507	2264	8432	7887	93
AP 40	77	4	3961	2703	2098	8762	7885	93
Apollo Supreme	91	3	3710	2524	2441	8675	7860	93
Barrier	91	3	3975	2569	2259	8802	7815	92
Oneida VR	87	3	3784	2585	2091	8460	7497	88
Sitel	87	4	2868	2121	2288	7276	7252	86
Mean	88	3	3982	2738	2332	9053	8269	
F Value	1.96**	2.11**	1.94**	1.02	2.24**	1.63*		
L.S.D. (P=.05)	12	1	798	NS	485	1505		
CV (%)	10.9	22.4	16.0	21.8	16.6	13.3		

[1] Vigor ratings 1 = poor, 9 = excellent.

DISEASES

I. Background and objectives

Verticillium wilt assessment/survey: Verticillium wilt is a serious disease of irrigated alfalfa in Alberta, but is rarely found in dryland fields. The disease was reported in the Outlook district and along the South Saskatchewan River near the Alberta border in 1980-84 and control measures were implemented. This survey was intended to evaluate the spread of the disease and assess the success of disease control measures.

Cottony snow mold trial: Trials to examine the resistance to cottony snow mold, and the impact of this disease on yield were in place at four sites throughout Saskatchewan. Plants which lack hardiness were thought to be more susceptible to the disease. This was especially true when the plants were not allowed to harden off completely. Therefore, it appeared that aggressively managed, irrigated alfalfa might be particularly at risk from this disease, and an irrigated site was added to the co-operative trial to examine this possibility.

Alfalfa-winter wheat rotation trial: In the early 1980's, winter wheat acreage was expanding rapidly throughout Saskatchewan. However, there were several reports of very poor winter wheat survival where it was grown following alfalfa. It was thought that this might be due to snow mold pathogens, especially cottony snow mold, which could build up for several years on alfalfa, and then damage the winter wheat, which is more susceptible to this pathogen.

II. Experimental Method

Verticillium wilt assessment/survey: Surveys of irrigated alfalfa fields in the central and western portions of the grainbelt were made from 1987-89, with 50 fields examined in 1987, 30 fields in 1988 and 31 fields in 1989. Field diagnosis based on symptoms was confirmed by isolation of the pathogen on water agar on the laboratory bench. Identification of foliar diseases was based primarily on symptoms, but occasionally isolations were made to confirm the diagnosis.

Cottony snow mold trial: Eight varieties of alfalfa recommended for Saskatchewan and one advanced line were seeded in 1986 at SIDC at Outlook in a 4-replicate split plot design with cultivars as main plots, and inoculation treatment as subplots. The plots were trimmed twice in the establishment year to limit weed seed dispersal. Two forage cuts were taken in 1987 (July 3 and August 18) and three in 1988 (June 15, July 25 and September 1) and 1989 (June 28, August 1 and October 1) and the lines were compared on a dry weight basis. Inoculum of Coprinus psychromorbidus isolate Ju714A was grown on killed rye grain, dried, and stored at $-7^{o}C$ until required. One-half of each main plot was inoculated with $10g/m^2$ of dried inoculum on October 21, 1987 and September 15, 1988. In 1988 and 1989, snow fences were set up in the plots in late fall to increase the snow catch. Alfalfa roots were collected from each main plot in the fall of 1988 and 1989 and assessed for root and crown rot severity. Foliar leaf disease levels were low during the study period, and there were no obvious differences in disease severity, so only two disease assessments were made. The plots were assessed each spring for survival and snow mold injury.

Alfalfa-winter wheat rotation trial: This trial was seeded in 1986 at SIDC. It was a 4-replicate trial with 4 treatments: 1) Beaver alfalfa - break in 1988 and seed to Norstar winter wheat, 2) Beaver alfalfa - break in 1989 and seed to winter wheat, 3) Puma fall rye 1986 and 1987 - seed to winter wheat in 1988, 4) Puma fall rye 1986-88 - seed to winter wheat in 1989. Each plot was 10 x 13 m, and was divided in two, one half treated with 10 g/m^2 of inoculum of Coprinus psychromorbidus in the fall of 1987 and the other left as a control. Spring survival was assessed in all plots. There was no disease in the inoculated plots in 1988, so all the breaking/seeding with winter wheat treatments were delayed by one year. We experienced problems with inoculum production in 1988, and there was not enough inoculum to treat this trial. However, treatments 1, 3 and 4 were seeded with winter wheat in September 1989, and will be assessed for survival in the spring of 1990.

III. Results and Discussion

Verticillium wilt assessment/survey: Verticillium wilt was found in nine alfalfa fields in the Leader area along the South Saskatchewan River near the Alberta border. Where the disease was present in young stands, seed used for planting had been purchased from Alberta, and the most likely source of the disease in these fields was seed-borne inoculum. The disease spread quickly in crops where good management resulted in high yield, probably as a result of the higher frequency of cutting, which transports the disease from plant to plant. In older, less productive stands, symptoms were less visible and the pathogen was probably spreading more slowly. With the help of the local extension agrologist, all the growers with infected fields have been contacted and these fields should be removed within two years. Disease control through plow-down of infected fields has been successful in eradicating the diseases from the Outlook and Miry Creek irrigation districts, where verticillium wilt had been observed in 1980-84. The predominant foliar disease observed was spring black stem, although common leaf spot was more severe in the Outlook region in 1988.

Cottony snow mold trial: In the three years of testing, there was no cottony snow mold injury observed in this trial. Relatively deep snow cover which persists for extended periods is necessary for the development of snow molds, and snow accumulation during the study period was below normal. Snow trapping on a similar test under irrigation at Swift Current resulted in a severe snow mold epidemic in 1988-89. However, yield losses in that test were equal to or lower than those observed in trials in northern regions, suggesting that irrigated alfalfa is not particularly susceptible to snow mold damage. Also, the causal organism dies out after only a few seasons if new hosts are not infected. These two observations indicate that irrigated alfalfa in central and southern areas, where snow accumulation is generally minimal, is not at particular risk from this disease. Yield and spring vigor assessments are presented in Table 11. Beaver and Algonguin, two established varieties with moderate regrowth potential and good winter hardiness, produced the highest yields in this trial.

Root disease assessments are presented in Table 12. Inoculation had a significant effect on root and crown rot severity, but the interaction between inoculation and variety was significant, which shows that the effect of inoculation on root diseases was not consistent for all the cultivars.

Table 11. Dry matter yields of 9 alfalfa lines under irrigation at SIDC, 1987-89.

Cultivar	Yield (Kg/ha)				Spring Vigor[§]
	1st cut	2nd cut	3rd cut[¶]	Total	
Beaver	4300	5000	3000	11400 a[δ]	3.1 ab
Algonquin	3900	5400	2800	11200 ab	2.8 b
120	4000	4900	3300	11100 ab	2.9 b
Anchor	4000	4900	3000	10900 ab	3.4 a
Apica	4100	4700	2900	10700 ab	3.2 ab
Vernal	4000	4700	2900	10600 ab	3.1 ab
S-7312	4100	4300	2600	10000 bc	3.0 ab
Heinrichs	3800	3700	2500	9200 c	3.2 ab
Rambler	4200	3600	2000	9200 c	2.8 b

[¶] Only 2 cuts taken in 1987.
[§] Spring vigor was measured on a 5 point scale (0 = no growth, 4 = best growth).
[δ] Values within a column which are followed by the same letter are not significantly different (P = 0.05) based on Duncan's Multiple Range Test.

Table 12. Mean root and crown disease severity of nine alfalfa lines at SIDC, 1988-89.

Cultivar	Root Rot[¶]		Crown Rot	
	Inoc[§]	Control	Inoc	Control
Beaver	.49	.41	.58	.51
Algonquin	.45	.40	.52	.40
Vernal	.48	.43	.52	.38
Apica	.49	.44	.51	.49
Anchor	.48	.52	.48	.50
Rambler	.44	.42	.47	.45
Heinrichs	.47	.44	.47	.43
S-7312	.47	.41	.45	.44
120	.37	.51	.39	.54

[¶] Root and crown rot were rated on a 4 point scale (0 = no rot symptoms, 1 = < 25% affected, 2 = 25-50%, 3 > 50% affected. Each category rating is converted to a mean severity using the middle of the range assessed i.e. 1 = .125, 2 = .375 and 3 = .75.
[§] Inoc. = Treated with 10 g/m^2 of inoculum of Coprinus psychromorbidus.

Alfalfa-winter wheat rotation trial: No snow mold damage was observed in the plots in the spring of 1988 or 1989. The trial needs to be continued for at least one more year to assess the effect of alfalfa in the rotation on winter wheat establishment and survival.

FORAGE GRASSES

I. Background and objectives

Kentucky Bluegrass Seed Production: Kentucky bluegrass is the main amenity turf grass species grown in western Canada. However, seed of this species is produced primarily in the north-western U.S.A., with some dryland production in north-eastern Saskatchewan. Production under irrigation has been examined in the past, but research has not been active in recent years, and no commercial production under irrigation was in place when this study was initiated.

Species Test (Forage): The yield of forage grasses under irrigation has not been examined in Saskatchewan for several years, so recommendations are based on old varieties and minimal management. We require updated information on varieties, and information on feed quality.

Species Test 2 (Forage): This test was designed to investigate the production of a number of grass species under an intensive cutting regime, focusing on current cultivars.

II. Experimental Method

Kentucky Bluegrass Seed Production: Three varieties and two lines of Kentucky bluegrass were seeded in a 4-replicate RCBD at SIDC in 1987. The rows were spaced 1 m apart. Each plot consisted of of 3 rows, each 6 m long. Seed was harvested in July of 1988 and 1989. In 1987 and 1988, tillage was used to control weeds between the rows and to maintain the crop in discrete rows. In 1989, tillage was discontinued and the rows were burned after harvest. This trial was also conducted at Saskatoon, where it was seeded in 1986 and seed harvests were taken in 1987 and 1988. In 1989, there was no measurable seed yield from the plots at Saskatoon.

Species Test (Forage): The five bluegrass lines examined in the seed production trial were included in this trial, together with six other forage grass species, in a 4-replicate RCBD trial at SIDC seeded in 1987. The plots were harvested three times in 1988 (June 1, July 6 and August 19) and 1989 (June 12, July 21 and August 30). Each harvest was followed by application of approximately 75 kg/ha of actual nitrogen, applied as 34-0-0. Spring vigour was assessed in May 1989. The forage quality of the bluegrass lines is being assessed using Near-Infra-Red Spectroscopy (NIR). To do this, a subset of samples was assessed chemically for protein content, and acid and neutral detergent fiber. The NIR instrument was calibrated based on this subset. Analysis of the bulk of the samples is in progress.

Species Test 2 (Forage): In 1988, strains of 12 grass species replicated five times were seeded in 1.3 x 6 m plots. Nitrogen fertilizer was applied at a rate of 100 kg N/ha in the fall of 1988, and again in spring, and late July in 1989. Fall soil tests in 1989 indicate a need for N, P, K, and S in 1990. The plots were cut for yield estimates on June 12, July 21, and August 30 in 1989.

III. Results and Discussion

Kentucky Bluegrass Seed Production: There was a very highly significant interaction between year, location and cultivar in this test. This interaction was so pronounced that there was little point in doing detailed comparisons among the factors. As an example, note the change in yield between 1987 and 1988 at Saskatoon in Table 13. Dormie was generally superior in seed yield to the other named cultivars, but we need an additional two years of data to properly evaluate this trial. Sod-bound bluegrass seed crops produce little or no seed, as was illustrated at Saskatoon in 1989. We hope that by burning the stand at Outlook after harvest, we have thinned the thatch sufficiently to get a good harvest in 1990. These yields are low relative to bluegrass seed production under irrigation in other regions. In 1989, a grower in the Bursay district harvested an estimated 1000 kg/ha of Dormie seed from a 70 acre field, but he did not get any seed crop in 1988. While most growers (and researchers!) will not get yields approaching 1000 kg/ha, the potential exists for economic production of bluegrass seed in this region. A study of the cultural practices required for high seed yield is needed.

Table 13. Mean Kentucky bluegrass seed yields from Outlook in 1988 and 1989 and Saskatoon in 1987 and 1988[¶].

Cultivar	Seed Yield (kg/ha)				
	Saskatoon		Outlook		Mean
	1987	1988	1988	1989	
S-8607	401	65	57	155	169
Dormie	333	77	61	190	165
Delta	177	68	126	133	126
S-7766	130	37	77	113	89
Troy	127	30	44	85	71
Mean	234	55	73	135	
C.V. (%)	12	35	17	24	
L.S.D. (P=.05)	42	30	19	50	

[¶] There was no harvestable seed yield at Saskatoon in 1989.

Species Test (Forage): This test is part of a co-operative test being run at Agriculture Canada Research Stations at Saskatoon, Swift Current and Lethbridge. The results of the test are quite different from those at the other sites, and the trial should be continued for at least two more years to determine if the results are indeed site-specific, or if yields in future years will fall more in line with our expectations. There were no significant differences in overall yield among the grass species, despite the large range in yields. Also, the spring vigor assessments for meadow fescue are quite unexpected. At Outlook, meadow fescue had the highest spring vigor rating in the trial. However, at Saskatoon, it suffered severe winter injury in 1988-89, and was very slow to come back. Winter hardiness is generally fair in meadow fescue although it is a short-lived perennial.

The high variability in this test (the coefficient of variability averaged almost 45% over the two years) is a problem. The average over all the tests at other sites is closer to 25%. This could have had a major impact on the results. The test at Outlook has been harvested with a sickle-blade harvester (because that is what is available at SIDC), whereas other tests in the trial have been harvested with a flail-type harvester. The sickle blade is not as efficient in picking up soft-stemmed grasses. This is apparent in the results of this trial, where the more upright grasses like meadow fescue are the highest producers (Table 14). Whether this is an artifact of the harvesting system, or a real difference in productivity needs to be examined

Table 14. Mean dry matter yields and spring vigor of seven forage grass species under irrigation at Outlook, 1988-89.

Species	Forage dry matter yield (kg/ha)				Spring Vigor¶
	Cut 1	Cut 2	Cut 3	Total	
Meadow fescue	4500	2100	2200	8700	2.5
Timothy	3400	2300	2700	8400	1.3
Reed canarygrass	3500	2000	2400	7900	2.3
Orchard grass	3500	2000	2200	7800	1.5
Meadow bromegrass	3500	1700	2300	7500	2.1
Smooth bromegrass	3500	1700	2100	7400	1.8
Kentucky bluegrass	2900	2100	2300	7300	1.6
Mean	3300	2000	2300	7600	
C.V. (%)	50	50	37	36	
L.S.D. (P = 0.05)	1650	995	856	2720	

¶ Vigor was measured in the spring of 1989. It was assessed on a 5-point scale, where 0 = no growth and 4 = excellent growth. There were no significant differences among species in forage yield or spring vigor.

thoroughly. However, the results show quite clearly that several of the grass species tested produce excellent forage yields under irrigated conditions when fertility is adequate. Adequate N fertilizer is important for high yields. After two years of applying more than 200 kg/ha of actual N per year to this trial, soil tests indicated very low levels of N (less than 20 kg/ha) in the surface 30 cm of soil.

A number of samples of Kentucky bluegrass forage have been chemically analyzed for quality parameters, and these results have been used to produce a calibration for NIR analysis of the remaining samples. Similar calibration sets have been developed recently at Agriculture Canada at Saskatoon for most of the forage species included in this trial. Samples used for this calibration were taken from tests at Saskatoon (1988), Outlook (1988) and Swift Current (1987 and 1988). The mean protein in the samples was 17.4%, with a range from 2.9-25.3%. The mean NDF was 63.4%, with a range of 52.5-73.4%, and the mean ADF was 30.5%, with a range of 22.7-39.7%.

Species Test 2 (Forage): The results (Table 15) are based on a single year of data, and must be considered as preliminary only. Champ timothy, and hard fescue were subject to seeding failure, and were reseeded in 1989. A few observations were noteworthy. Revenue slender wheatgrass showed superior establishment vigor and stand development in the seeding year. Kirk crested wheatgrass provided superior yields in cut 1 and 2 in 1989. Meadow bromegrass was marginally inferior to Smooth bromegrass in the first two cuts, and in total yield. Courtenay tall fescue was superior to Mustang in all cuts, and gave the the highest yield of all species in the last growing period. S-9071, a winterhardy strain of orchardgrass, showed the lowest yields of the orchardgrass varieties tested. This test will be harvested for at least two more years.

Table 15. Irrigated Species Test - Seeded 1988 (Test 2).

Species & Strain	Seeding[¶] Failure (5 plots)	1988[§] Fall Vigor	1989[§] Spring Vigor	Forage Yields (kg/ha)[δ] Cut1	Cut2	Cut3	Total	% of Carlton
Crested wheatgrass								
Kirk	2	1	5	7930	3392	1118	12440	107
Smooth bromegrass								
Carlton	2	2	5	6158	3017	2431	11606	100
S-7133K	0	4	5	6294	2288	1634	10216	88
Meadow bromegrass								
Fleet	1	2	4	5986	1813	2494	10293	89
Slender wheatgrass								
Revenue	0	3	5	6111	3416	819	10346	89
Tall fescue								
Courtenay	2	5	2	2245	2596	4709	9550	82
Mustang	1	5	2	1586	1406	2251	5243	45
Meadow fescue								
Beaumont	2	4	2	1985	1429	1398	4812	41
Timothy								
Climax	1	3	3	2172	1333	982	4487	39
Champ	4	2	3	1705	1620	1085	4409	38
Orchardgrass								
Kay	1	4	2	783	1319	1174	3275	28
Chinook	1	4	1	1286	992	930	3207	28
S-9071	1	2	1	860	1294	884	3036	26
Hard fescue								
Common	1	2	1	2323	384	494	3102	27
Mean				3382	1881	1627	6866	
F Value				52.91**	13.50**	9.96*	26.82**	
C.V. (%)				22	30	47	23	
Waller MSD (P = 0.05)				866	667	934	1808	

[¶] Seeding failure noted out of 5 plots.
[§] Regrowth scores are visually rated on a scale of 1-5 with 5 being the best.
[δ] Cut 1 - June 12, Cut 2 - July 21, Cut 3 - August 30.

Overall Statement of Conclusions and Impact

The alfalfa seed production studies demonstrated that the appropriate irrigation management package, coupled with leafcutter bee pollination and insecticide applications to control plant bugs, can result in excellent yields of alfalfa seed. Curtailing irrigation when plants began to bud stressed the crop slightly and promoted flovering. The year i.e. the heat and sunshine which directly affected pollinator activity, greatly influenced subsequent yield, while stand density did not. Four years after initial establishment, plant stands were uniform despite different seeding methods and cultivation practices. Plant bug populations reached economic thresholds and had to be controlled each year. Leafcutter bees were effective pollinators and were not adversely affected by the exposed nature of the field. High bee cell parasitism levels indicate that arasite control is required when incubating cells before release of adults in the spring. Key factors for successful production of alfalfa seed under irrigation in the Outlook area include good stand establishment, heavy irrigation until the prebud stage of alfalfa growth, weed and pest insect control, and proper management of leafcutter bees.

The success of this study has encouraged two growers in the Outlook region to establish 35 acre demonstration plots of alfalfa for seed. Another grower has sown 70 acres of bluegrass for seed production. The alfalfa variety trials are filling an important gap which currently exists in recommendations for varieties under irrigated conditions, and the improved recommendations arising from these studies should continue to have an impact on irrigated forage production well into the future. The forage species studies demonstrate the potential of a number of grass species under irrigated conditions. While conclusions are limited due to insufficient years of data, continued production data over the next two growing seasons will provide insight into the potential for utilization of these species.

List of papers and presentations

Gossen, B.D. and Jesperson, G.D. 1990. Verticillium wilt of irrigated alfalfa in Saskatchewan 1987-89. Can. Plant Dis. Surv. (Submitted)

Gossen, B.D. and Jesperson, G.D. 1990. Verticillium wilt of irrigated alfalfa in Saskatchewan in the 1980's. Sask. Forage Council Newsl. (Submitted)

Gossen, B.D. and Jesperson, G.D. 1990. Verticillium wilt of irrigated alfalfa in Saskatchewan in the 1980's. Pages 28-31 in Research Highlights 1989, Agric. Canada Res. Stn., Saskatoon.

Goplen, B.P. and Soroka, J.J. 1989. Irrigated alfalfa seed production research at SIDC. Pages 3-4 in Irrigation Research and Demonstration News. SIDC, Outlook, December 1989.

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Gossen, B.D., Soroka, J.J. and Goplen, B.P. 1989. Management for alfalfa seed production under irrigation. Poster display at ADF Conference, October 24-26, 1989, Regina, Saskatchewan.

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Goplen, B.P., Gossen, B.D. and Soroka, J.J. 1987. Management of forage production under irrigation. Page 9 in Report on Research and Demonstration Highlights. SIDC, Outlook.

Personnel involved in the project

Scientists/Biologists	% of Time
Dr. B. Harvey	-
Dr. B.P. Goplen	5%
Dr. B.D. Gossen	25%
Dr. J.J. Soroka	15%
H. Ukrainetz	8%
S.B.M. Wright	
Technical assistants	
W.W. Reiter	10%
H. Kinzel	10%
J.L. Nerland	15%
C.H. Duncan	5%
A.O. Arnelian	8%
C. Slater	5%
2 summer students	4 months per year
1 supervisor	6 months per year